THE EFFECTS OF DIFFERENT DISTRACTION FREQUENCIES ON AXON MORPHOMETRY FOLLOWING A TWO MONTH CONSOLIDATION PERIOD IN A RABBIT MODEL

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Introduction:
Despite advances in limb lengthening, neurovascular complications still occur. Two key parameters for successful distraction osteogenesis are: 1) an adequate period of consolidation and 2) distraction frequency. Several studies describe decreases in soft tissue resistance and improved nerve conduction with high versus low frequency distraction. Clinically, a distraction rate of 1 mm/day, to 30% of original length, followed by an appropriate consolidation period is often employed. Most limb lengthening peripheral nerve studies, describe nerve morphometry either immediately following distraction termination or following distraction at a rate greater than 1 mm/day. Thus, the impact of clinically physiologic limb lengthening on the peripheral nerve remains unclear. The study goals were to determine the effects of clinically appropriate limb lengthening, at high and low distraction frequencies, on internodal length and nerve morphology (diameter and composition). The study hypothesis was that following a consolidation period, nerve morphology following high frequency distraction would more closely resemble that of control than would those axons undergoing low frequency distraction.

Methods:
Ten rabbits were assigned to Group I (n=5): low frequency distraction (1 mm/day; 3 increments) or Group II (n=5): high frequency distraction (1 mm/day; 720 increments). External fixators were used to distract the left tibia until 30% diaphyseal lengthening was achieved (Figure 1). The contralateral limb was control. Two months after distraction termination, the external fixators were removed and the tibial nerve harvested. Axon teasing was performed to determine internodal length and nerve morphology (Figure 2).

Results:
Mean internodal lengths were not significantly different between the high and low frequency distraction groups. However, the mean overall axonal diameter was decreased, compared to control, in both Group I (16.35 ± 5.9µm vs. 14.2 ± 4.2µm; p<0.01) and Group II (16.73 ± 5.4µm vs.14.3 ± 4.3µm; p<0.01). This change in axonal diameter was significant in Aα fibers with diameters between 15-20µm (p<0.0028; Group I) and >20µm (p<0.0001; Groups I and II).

Discussion and Conclusion:
Thirty percent limb lengthening at a rate of 1 mm/day significantly decreased axon diameter, with the Aα motor fibers exhibiting the greatest change. Contrary to other studies, no increase in internodal length was observed. Thus, internodal length increases may be seen immediately after lengthening but return to normal lengths after a period of consolidation. However, further studies are necessary to fully determine the effects of the consolidation period on axon morphometry and the physiology of axon repair. A greater understanding of peripheral nerve responses to elongation may not only increase limb lengthening capabilities, but improve function following acute or chronic nerve repairs.

Figure 1. AP radiograph of an external fixator placed on a rabbit’s right hindlimb. Limb lengthening occurred at a rate of 1 mm/day over a period of approximately 30 days.

Figure 2. Example of a single axonal internode teased from an elongated tibial nerve from a rabbit. Sequential photos were taken along the internode then reconstructed using photoshop software. Internodal length and diameter were subsequently measured.